Deformation of Materials - 2

1.

(a) Define

(i) stress .....

.....

(ii) strain .....

.....[2]

(b) **(i)** Distinguish between elastic and plastic behaviour when materials are stretched.

.....

.....

.....[2]

(ii) Define elastic limit.

.....

.....[2]

(c) **(i)** State the SI unit of the Young modulus.

unit .....

(ii) Describe, with the aid of a diagram, an experiment to determine the Young modulus of steel in the form of a wire. Explain how to use your readings to obtain the Young modulus. (You will be awarded marks for the quality of written communication in this part of the question.)

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[8]

2.

(a) State Hooke's Law.

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.....[1]

(b) A spring is compressed by applying a force. Fig. 6.1 shows the variation of the force *F* with compression *x*.

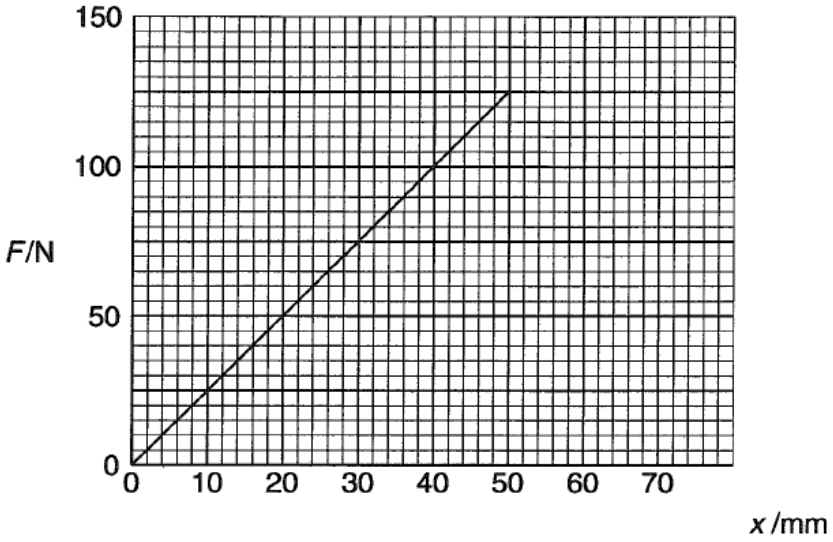

Fig. 6.1

(i) Calculate the spring constant.

spring constant = ... unit ..... [2]

(ii) Show that the work done in compressing the spring by 48 mm is 2.9 J.

[2]

(c) Fig. 6.2 shows the spring in a toy gun. The spring is used to fire a dart of mass 15 g vertically.

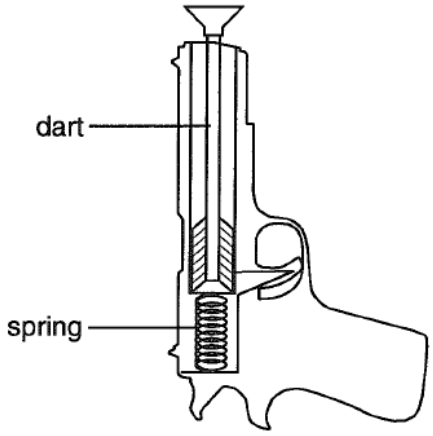

Fig. 6.2

(i) The spring is compressed by 48 mm in the gun. When the gun is fired the strain energy in the spring is converted into the kinetic energy of the dart. Calculate the speed with which the dart initially leaves the spring when the gun is fired.

speed = ... $m\,s^{-1}$ [3]

(ii) Give two reasons why the dart is unlikely to have 2.9 J of gravitational potential energy when it reaches its maximum height.

1. .....

.....

2. .....

.....[2]

3.

(a) (i) Define the Young modulus of a material.

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.....[2]

(ii) Define elastic limit.

.....

.....[2]

(iii) Distinguish between elastic and plastic deformation of a material.

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.....[2]

(b) Fig. 7.1 shows graphs of force *F* against extension *x* for three different types of material. Identify with a reason the type of material corresponding to each graph.
(In this question marks are available for the quality of written communication.)

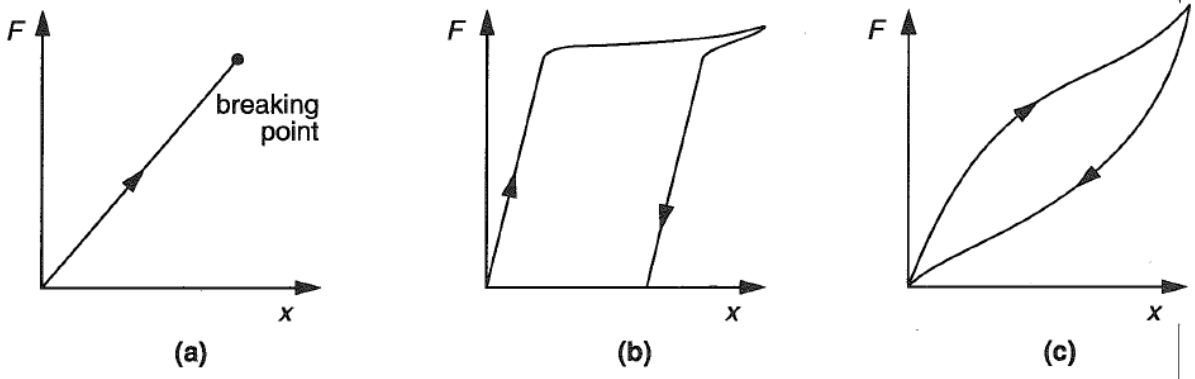

Fig. 7.1

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.....[5]

4.

(a) Define the *Young modulus* of a material.

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..... [2]

(b) A metal wire of length 1.80 m is clamped vertically and a load is applied so that it extends 0.55 mm. The cross-sectional area of the wire is 1.2×10^{-7} m^2 and the Young modulus of the metal is 2.0×10^{11} Pa.

(i) Calculate the strain.

strain = ...

(ii) Calculate the force applied.

force = ... N
[4]

(c) **(i)** Determine the extension produced on a second metal wire that has the same dimensions as the wire in part **(b),** has the same load applied but is made from a material that has half the Young modulus value.

extension = ... mm

(ii) State **one** assumption made.

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..... [3]

5.

(a) State Hooke's law.

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..... [1]

(b) Fig. 5.1 shows a graph of force F against extension e for a metal in the form of a wire. The cross-sectional area of the wire is $1.80 \times 10^{-7}\,m^2$ and its length is 1.70 m.

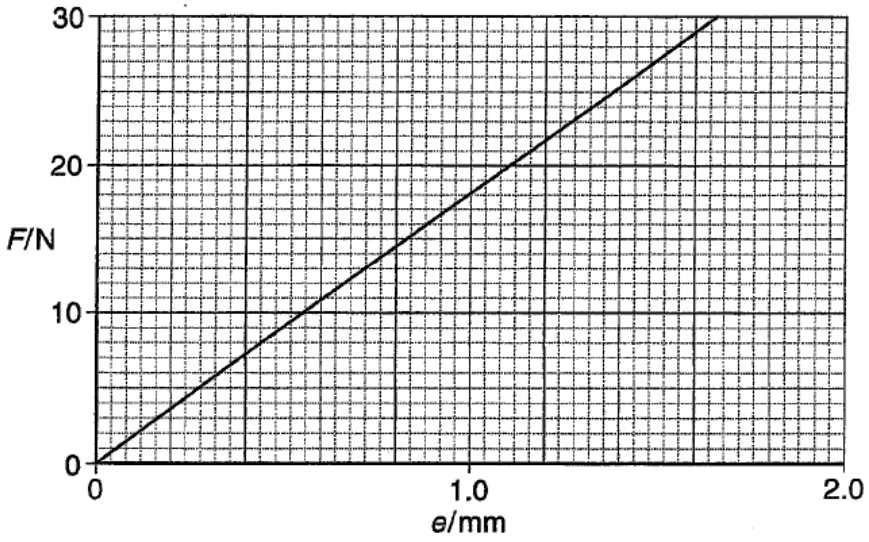

Fig. 5.1

(i) Calculate the Young modulus of the metal.

Young modulus = ... Pa [4]

(ii) Calculate the energy stored in the wire when it extended by 1.60 mm.

energy stored = ... J [3]

6.

(a) Define the *Young modulus*.

.....

..... [1]

(b) The wire used in a piano string is made from steel. The original length of wire used was 0.75 m. Fixing one end and applying a force to the other stretches the wire. The extension produced is 4.2 mm.

(i) Calculate the strain produced in the wire.

strain = ... [2]

(ii) The Young modulus of the steel is 2.0×10^{11} Pa and the cross-sectional area of the wire is 4.5×10^{-7} m^2. Calculate the force required to produce the strain in the wire calculated in **(i)**.

force = ... N [3]

(c) A different material is used for one of the other strings in the piano. It has the same length, cross-sectional area and force applied. Calculate the extension produced in this wire if the Young modulus of this material is half that of steel.

extension = ... mm [2]

(d) (i) Define *density*.

.....

..... [1]

(ii) State and explain what happens to the density of the material of a wire when it is stretched. Assume that when the wire stretches the cross-sectional area remains constant.

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..... [1]

7.

(a) When determining the Young modulus for the material of a wire, a *tensile stress* is applied to the wire and the *tensile strain* is measured.

(i) State the meaning of

tensile stress.....

.....

tensile strain.....

.....

(ii) Define the Young modulus.....

.....

(3 marks)

(b) **Figure 7** shows two wires, one made of steel and the other of brass, firmly clamped together at their ends. The wires have the same unstretched length and the same cross-sectional area. One of the clamped ends is fixed to a horizontal support and a mass M is suspended from the other end, so that the wires hang vertically.

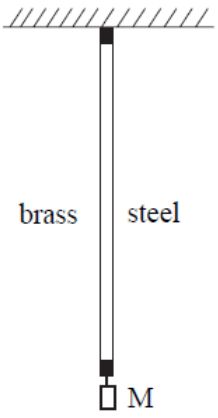

Figure 7

(i) Since the wires are clamped together the extension of each wire will be the same. If E_S is the Young modulus for steel and E_B the Young modulus for brass, show that

$$\frac{E_S}{E_B} = \frac{F_S}{F_B},$$

where F_S and F_B are the respective forces in the steel and brass wire.

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(ii) The mass M produces a total force of 15 N. Show that the magnitude of the force $F_S = 10\,N$.

the Young modulus for steel $= 2.0 \times 10^{11}\,Pa$
the Young modulus for brass $= 1.0 \times 10^{11}\,Pa$

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(iii) The cross-sectional area of each wire is $1.4 \times 10^{-6}\,m^2$ and the unstretched length is 1.5 m. Determine the extension produced in either wire.

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(6 marks)